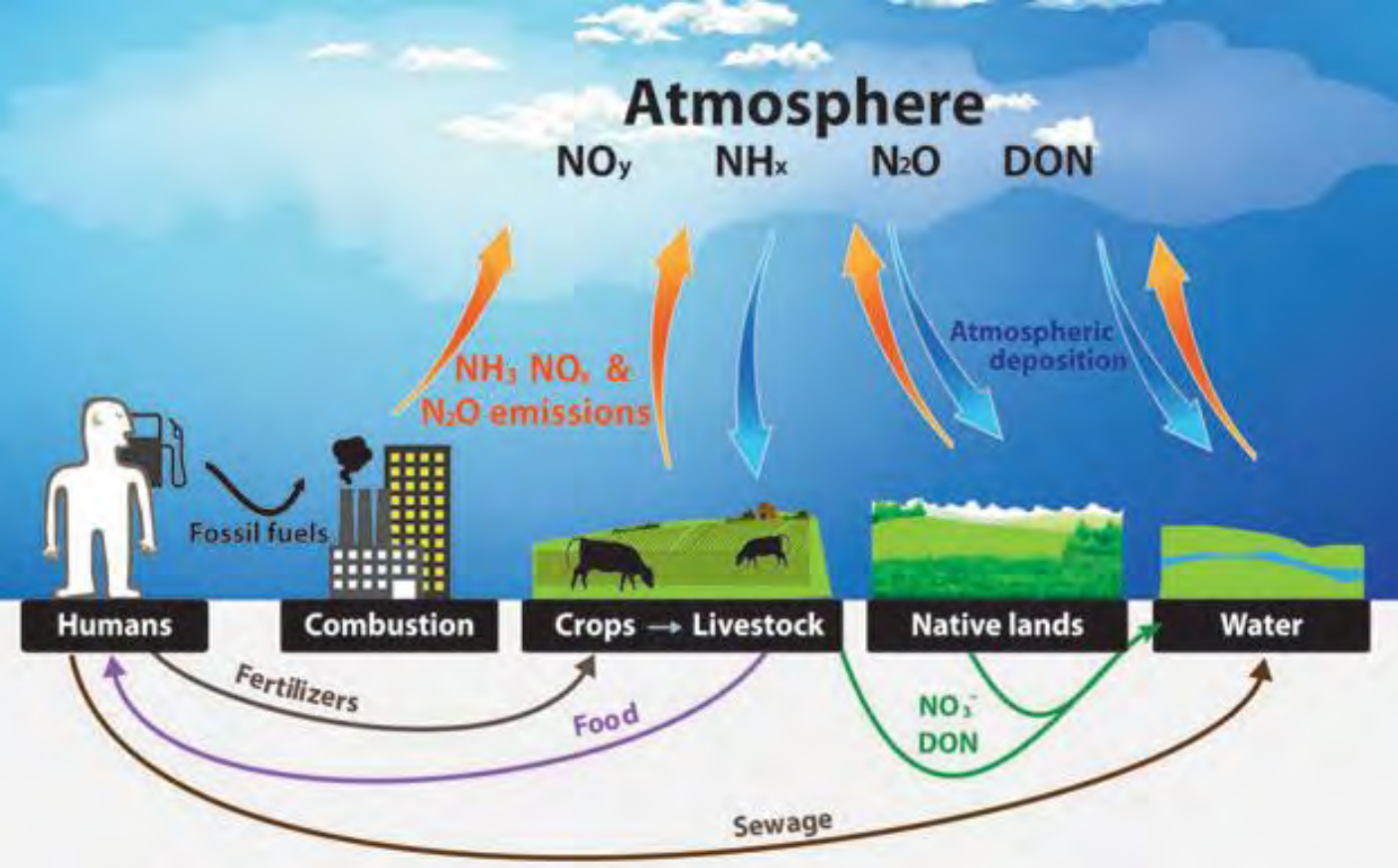


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June 4, 2013



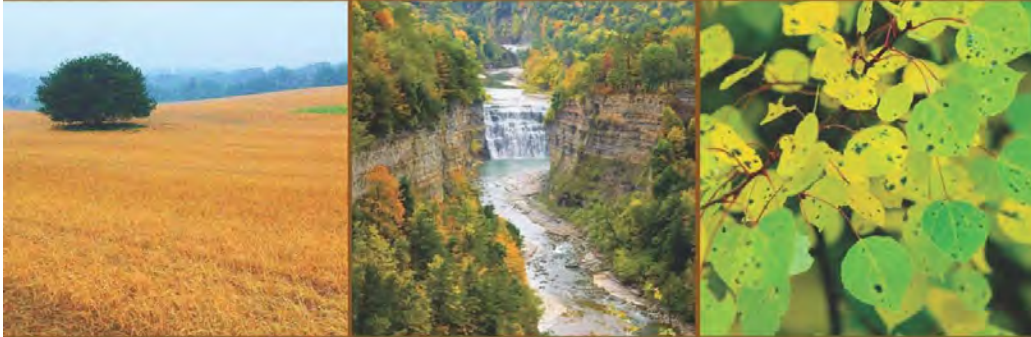
THE SAB'S REACTIVE NITROGEN IN THE UNITED STATES: THE RECOMMENDATIONS AND BEYOND

EPA-CSU Workshop
Fresno, California

Reactive Nitrogen Research
for San Joaquin Valley
Agriculture

Reactive Nitrogen in the United States: An Analysis of Inputs, Flows, Consequences, and Management Options

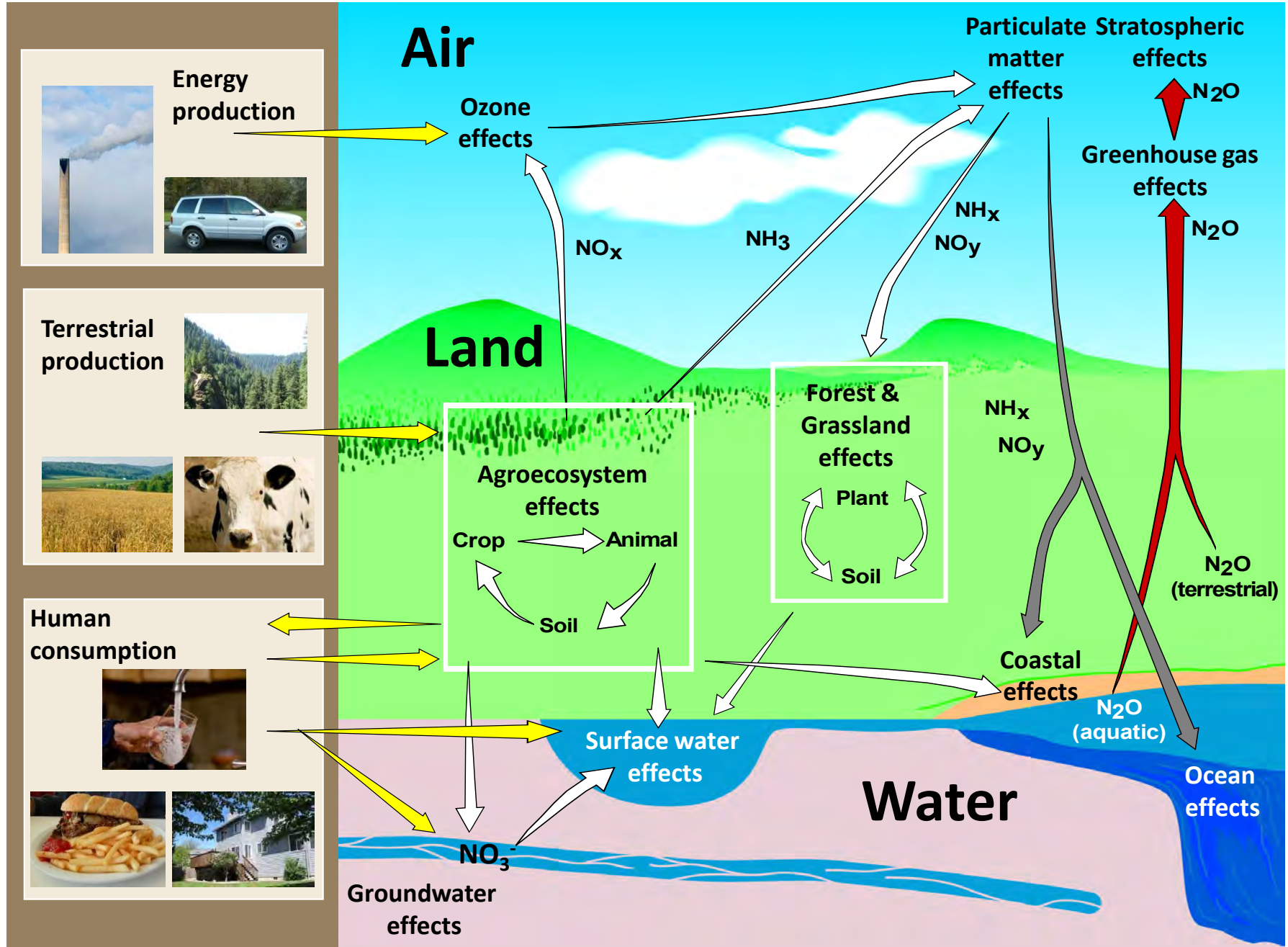
A REPORT OF THE EPA SCIENCE ADVISORY BOARD



Reactive Nitrogen in the United States: An Analysis of Inputs, Flows, Consequences and Management Options

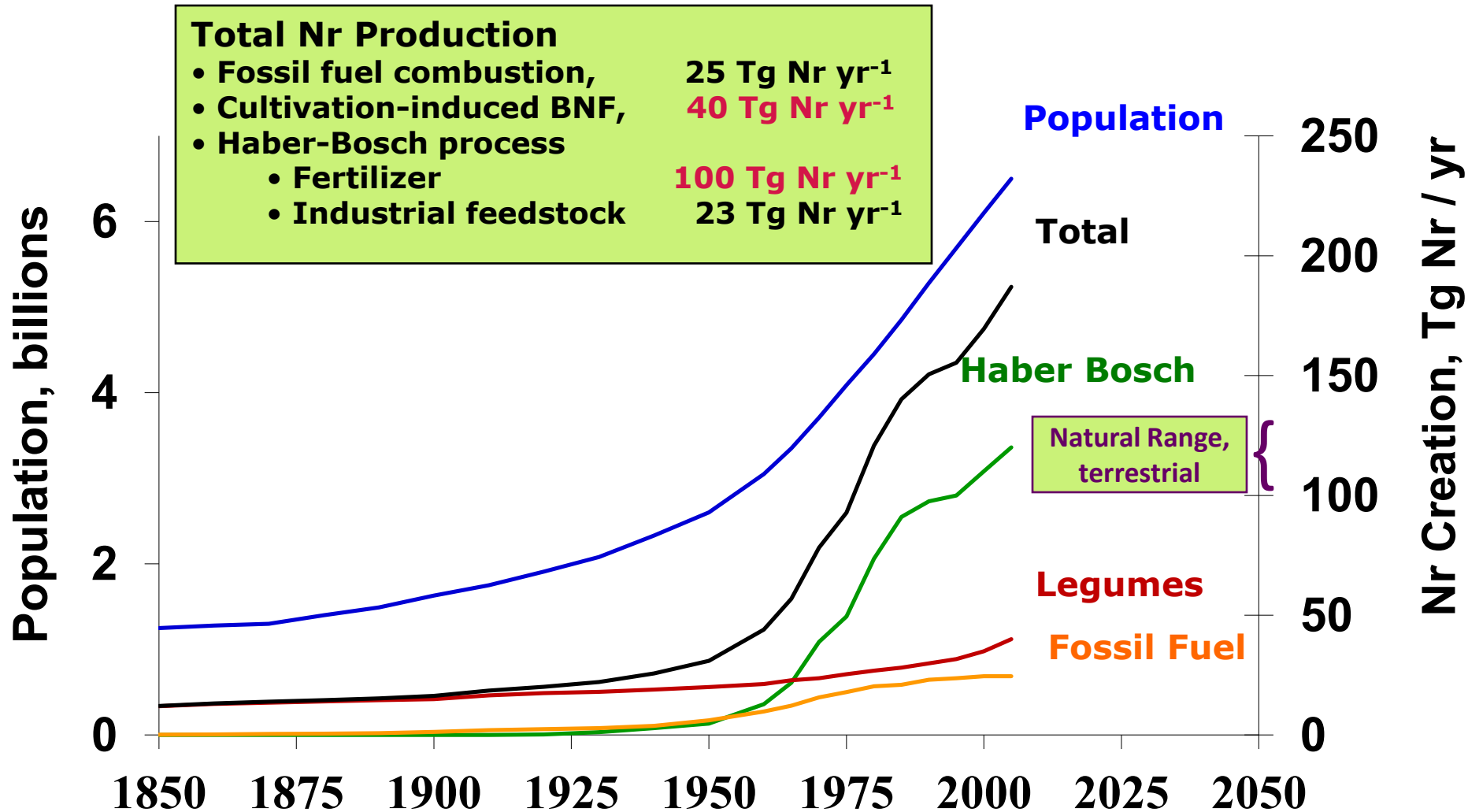
*-- EPA Science Advisory Board's
Integrated Nitrogen Committee
final report*

The nitrogen cascade



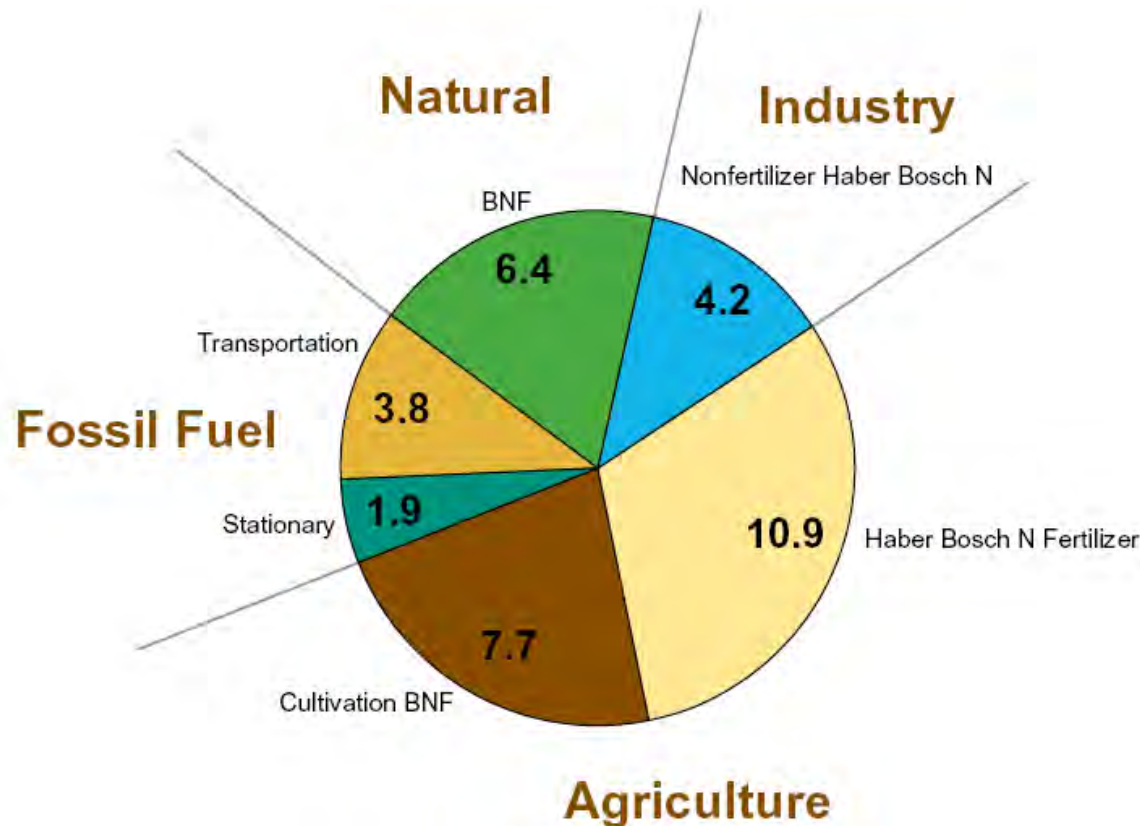
Global Nr Creation by Human Activity 1850 to 2005

In 2005 ~190 Tg Nr was created by humans.



Sources of Reactive Nitrogen

- Human Activities introduce five times more Nr into the U.S. environment than natural sources.
- The largest anthropogenic sources of Nr are: synthetic fertilizer, nitrogen fixing legumes, and fossil fuel combustion.



Agriculture— The 800 pound Gorilla

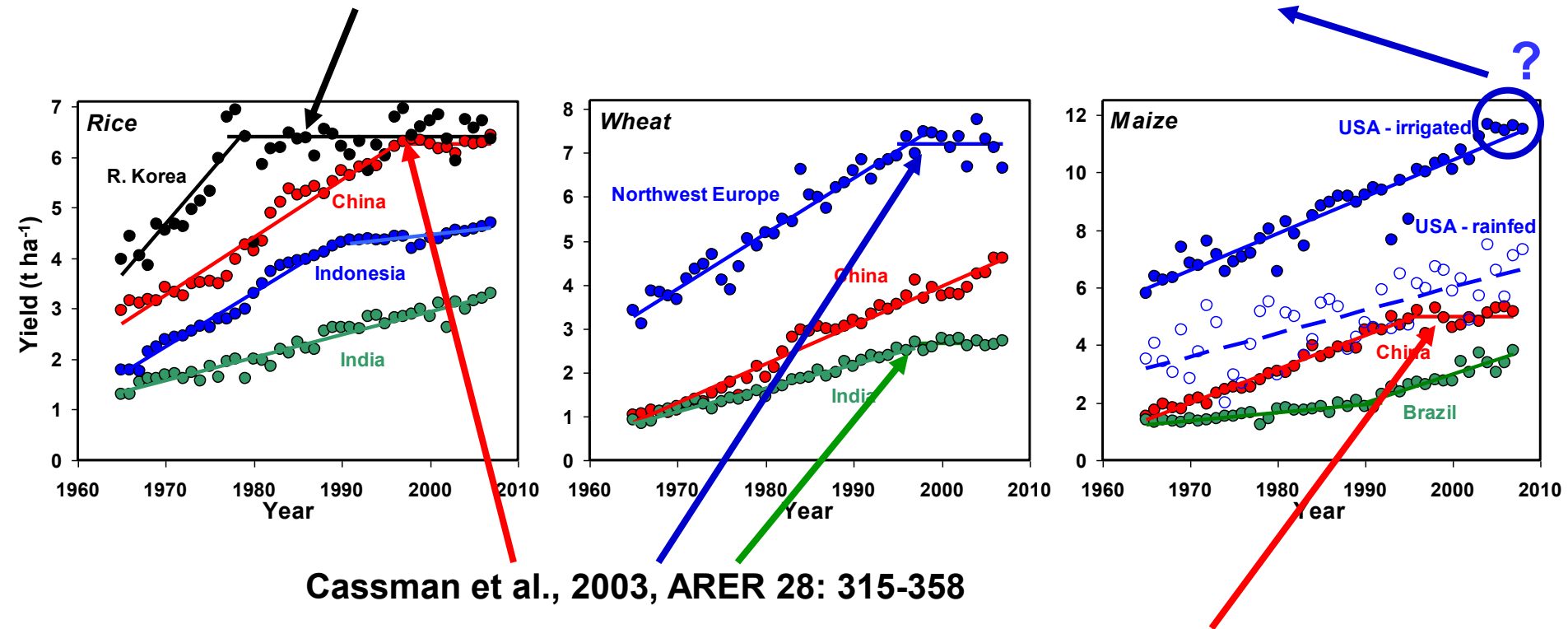
- We create Nr for a reason
- Trade-off = increased Nr and food production

Issue of Yield Plateaus and intensification

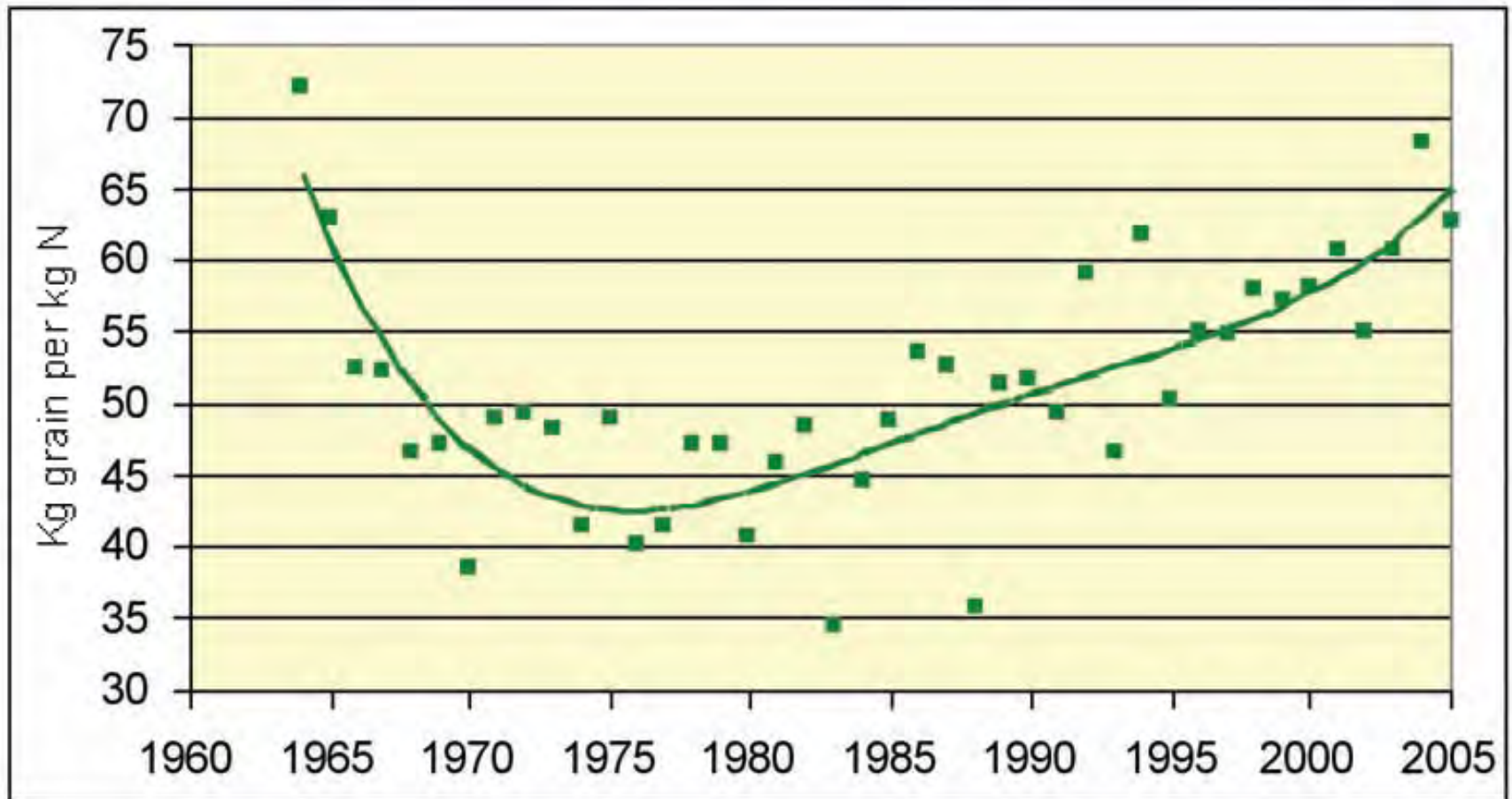
Korea and Yield plateaus are evident for several cereal crops in some major producing countries: *China for rice, wheat in northwest Europe and India, maize in China and.....perhaps also for irrigated maize in the USA.*

Cassman, 1999. PNAS, 96: 5952-5959

Grassini et al., 2011. FCR 120:142-152



U.S. Trends in Corn Grain Produced per unit Applied Fertilizer N



Overarching SAB Recommendations

- The nitrogen cascade should be used as a framework to understand the environmental impacts of reactive nitrogen as it moves through multiple ecosystems and media.
- Integrated cross-media management approaches and regulatory structures are needed to recognize tradeoffs and focus management efforts at points of the nitrogen cascade where they are most efficient and cost effective.
- EPA should form an intra-Agency Nr management task force to build on the existing breadth of Nr research and management capabilities within the Agency.
- EPA should convene an inter-Agency Nr management task force to coordinate federal programs that address Nr monitoring, modeling, research, and management.

Specific Recommendations

- EPA should consider a range of Nr risk management options including:
 - An evaluation of the full suite of regulatory and non-regulatory tools used to manage Nr to determine the most effective mechanisms to apply to each source.
 - Reexamination of the criteria air pollutant “oxides of nitrogen” to consider whether it should be supplemented with other indicators of chemically reactive nitrogen.
 - A policy, regulatory, and incentive framework to further limit the transport of applied nutrients off farms.
- EPA should undertake education, communication, and outreach to build public support for addressing the widespread problem of Nr.
- Additional Nr research and monitoring is essential to:
 - Reduce the margins of error in our current understanding of environmental Nr concentrations or flows.
 - Target actions to reduce excess Nr and understand the efficacy of management actions that have been taken.
 - Improve our understanding of the indirect impacts of Nr and the indirect impacts of measures to control Nr.

Goals for Management Action

- The SAB estimates that a 25% reduction in Nr introduced into the U.S. environment might be achieved with existing technology in the coming 10-20 years through actions that could be taken by EPA and other management authorities.
 - Expanded efforts to control emissions of NO_x from mobile sources and power plants could decrease the generation of Nr by 2.0 Tg/yr.
 - Increased crop uptake efficiencies (through advances in fertilizer technology) could further decrease Nr releases by 2.4.Tg/yr.
 - Livestock-derived NH_3 emissions could be decreased by 0.5 Tg/yr through a combination of BMPs and engineered solutions, and NH_3 emissions from fertilizer application could be decreased by 0.2 Tg/yr through BMPs related to application rate and timing.

Goals for Management Action

- Management actions to reduce Nr by 25% (continued)
 - Excess flows of Nr into streams, rivers and coastal systems could be decreased by 1 Tg/yr through improved landscape management (e.g., wetland creation and improved tile-drainage systems on cropland).
 - Removal of nutrients through sewage treatment infrastructure upgrades and stormwater and nonpoint source control could decrease Nr releases by 0.5 - 0.8 Tg/yr.
- These goals for management action represent realistic and attainable near-term outcomes, but further Nr reductions are needed for many N-sensitive ecosystems and to ensure that health-related standards are maintained.

Key Water Quality Recommendations

- Develop a uniform Nr assessment and management framework that considers loading over a range of scales, and includes all inputs related to atmospheric and riverine delivery to estuaries and their effects on eutrophication dynamics.
- Set Nr management goals on a regional/local basis.
- Address Nr runoff and discharges by reviewing current regulatory and nonregulatory programs and tools to determine adequacy and capacity to meet Nr management goals.
- Determine and apply the most effective regulatory and voluntary mechanisms to each Nr source type, paying special attention to the need to control nonpoint sources.
- Encourage wetland restoration and creation to promote denitrification.

Key Data Acquisition Recommendations

- Obtain more and better data to inform management decision-making
 - In partnership with other agencies, routinely and consistently account for presence of Nr in the environment using an integrated approach to monitoring that includes air, water, and land components.
 - Expand scope and spatial coverage of atmospheric Nr concentration and flux monitoring networks (e.g., National Atmospheric Deposition program, Clean Air Status and Trends Network).
 - Obtain better fertilizer application data for major crops and residential turf.
 - Monitor gas and particulate matter emissions from agriculture.
 - Begin air monitoring of NH_x and NO_y to supplement the existing network of NO_2 compliance monitors.

Key Research Recommendations

- Management Strategies Research
 - Understanding tradeoffs associated with management strategies for carbon, Nr and other contaminants.
 - Understanding the combined impacts of different Nitrogen management strategies on the movement of Nr across environmental media.
 - Understanding the effectiveness of best management practices (particularly for controlling Nr from nonpoint and stormwater sources).
 - Understanding how to manage the impact of Nr on ecosystem services.
- Agricultural research
 - Understanding and predicting how biofuel production will affect Nr inputs and outputs from agriculture and livestock systems.
 - Increasing gain in crop yields and Nitrogen Fertilizer use Efficiency.
 - Understanding nitrogen mass balance for crop agriculture.
 - Improving fertilizer application and formulation technologies.

Key Research Recommendations (continued)

- Nitrogen Budget Research
 - Quantifying the N budgets of terrestrial systems and the magnitudes of major loss vectors.
 - Quantifying denitrification in soils and aquatic systems.
- Measurement and Modeling Research
 - Improving analytical techniques for measuring atmospheric NO_y and NH_x and modeling the movement of Nr in the environment.
 - Cross-disciplinary research to model interactions of climate and Nr

Key Air Quality Recommendations

- Expand NO_x control efforts for emissions of mobile sources and power plants.
- Reexamine of the criteria air pollutant “oxides of nitrogen” to consider whether it should be supplemented with other indicators of chemically reactive nitrogen.
- Encourage states to address NH₃ as a harmful PM_{2.5} precursor.

Beyond the Biophysical Boundary

Institutional Alignment



**Cost
Effectiveness**

Point / Non-Point

Voluntary / Regulated

Beyond the Biophysical Boundary

Institutional Alignment Challenges

- Imperative of the Cascade
- Across Media, Sector and Scale
- Across authorities/jurisdictions

Institutional Examples

- EPA, USDA, ORSANCO, Iowa Soybean Assoc.

Beyond the Biophysical Boundary

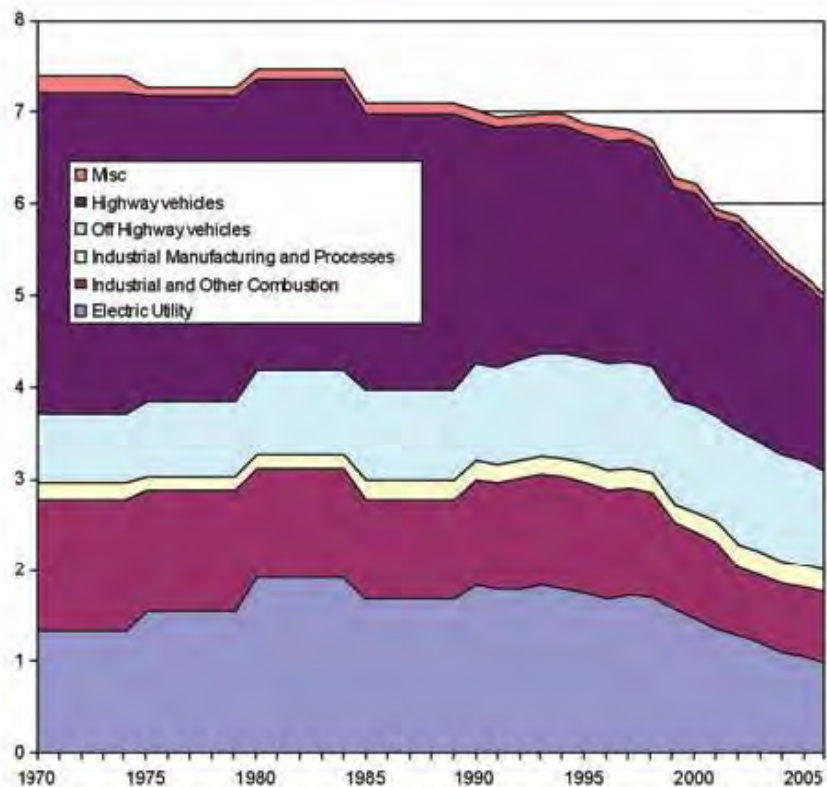
Voluntary/Regulated Challenges

- USDA Voluntary Tradition
 - Payments Expectation vs. Bush Tender
- Nebraska Water Districts
- Clean Water Act & '90 Clean Air Act Amendments
 - Cap and Trade
- Chesapeake Bay Hybrid

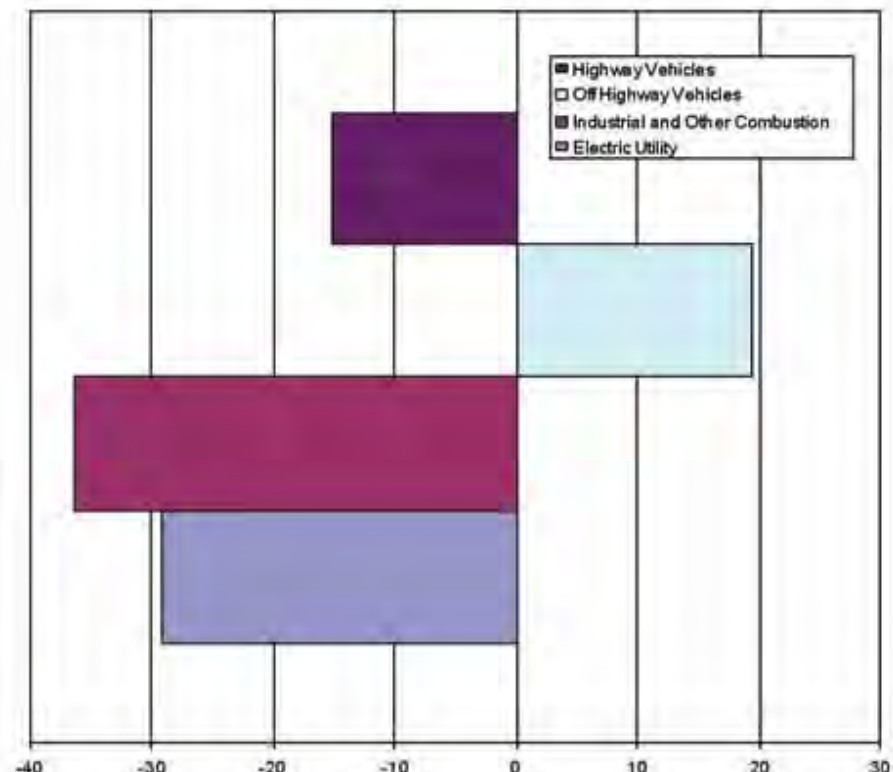
Point and Non-Point

- Alignment with regulated and voluntary
- Concentrated vs. Diffuse
- Monitoring and Assurance

Tg of Nitrogen (converted from short tons of NO_x as NO_2)



Year



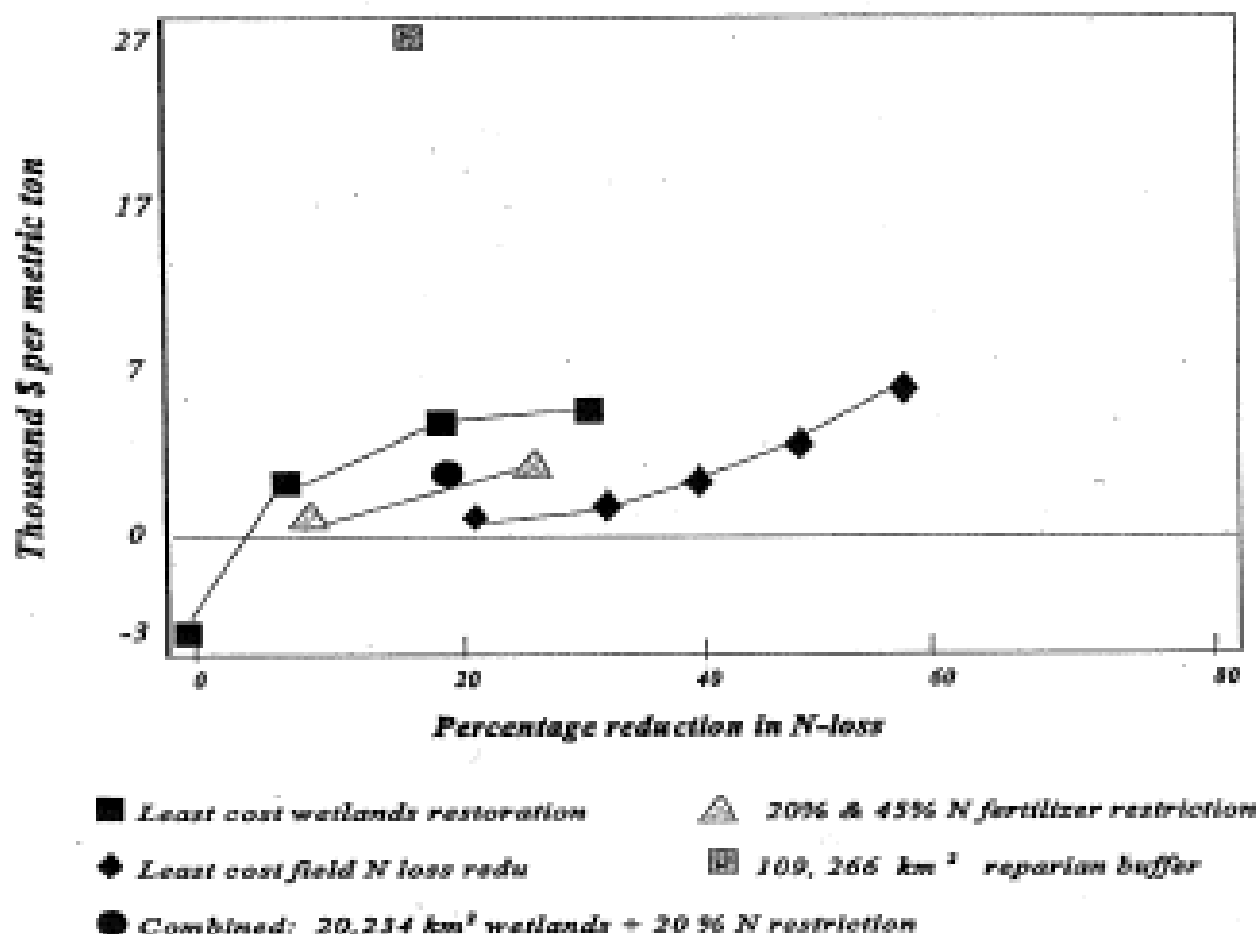
Percent change from 1990 to 2002

U.S. NO_x Trends & Reductions

Cost Effectiveness

- Within Sectors and Media
- Between Sectors & Media
- Key Role of Marginal Cost
 - Riding the lowest Marginal Cost Curve
- Net benefits

Agricultural sector adjustment costs per unit of N reduction, net of intrabasin benefits, by control method.



Includes net farm cash income, consumer surplus, and intrabasin benefits
Assumes 15 g/m² wetland and 4 g/m² buffer denitrification.

TABLE 2. Marginal Abatement Cost per Tonne of Nr by Source (\$ US 2000)

location in the N cascade where emitted	source/pollutant	abatement cost per tonne of Nr
air	electric utilities/NO _x (26)	\$4,800
	industrial/NO _x (27)	\$22,000
	mobile sources/NO _x (28)	\$14,000
	non-agricultural/NH ₃	no estimate
land	agriculture/nitrate (29)	\$10,000
	urban and mixed open land uses/nitrate (29)	\$96,000
freshwater	point sources/nitrates (29)	\$18,000

Metrics Matter

- What we measure, we do
- What we measure, we reward
- Change in metrics → Change in Goals & Actions

Example of Chesapeake Bay

- Tons of N versus dollars

Chemical Nitrogen Cascade: Chesapeake Bay Watershed

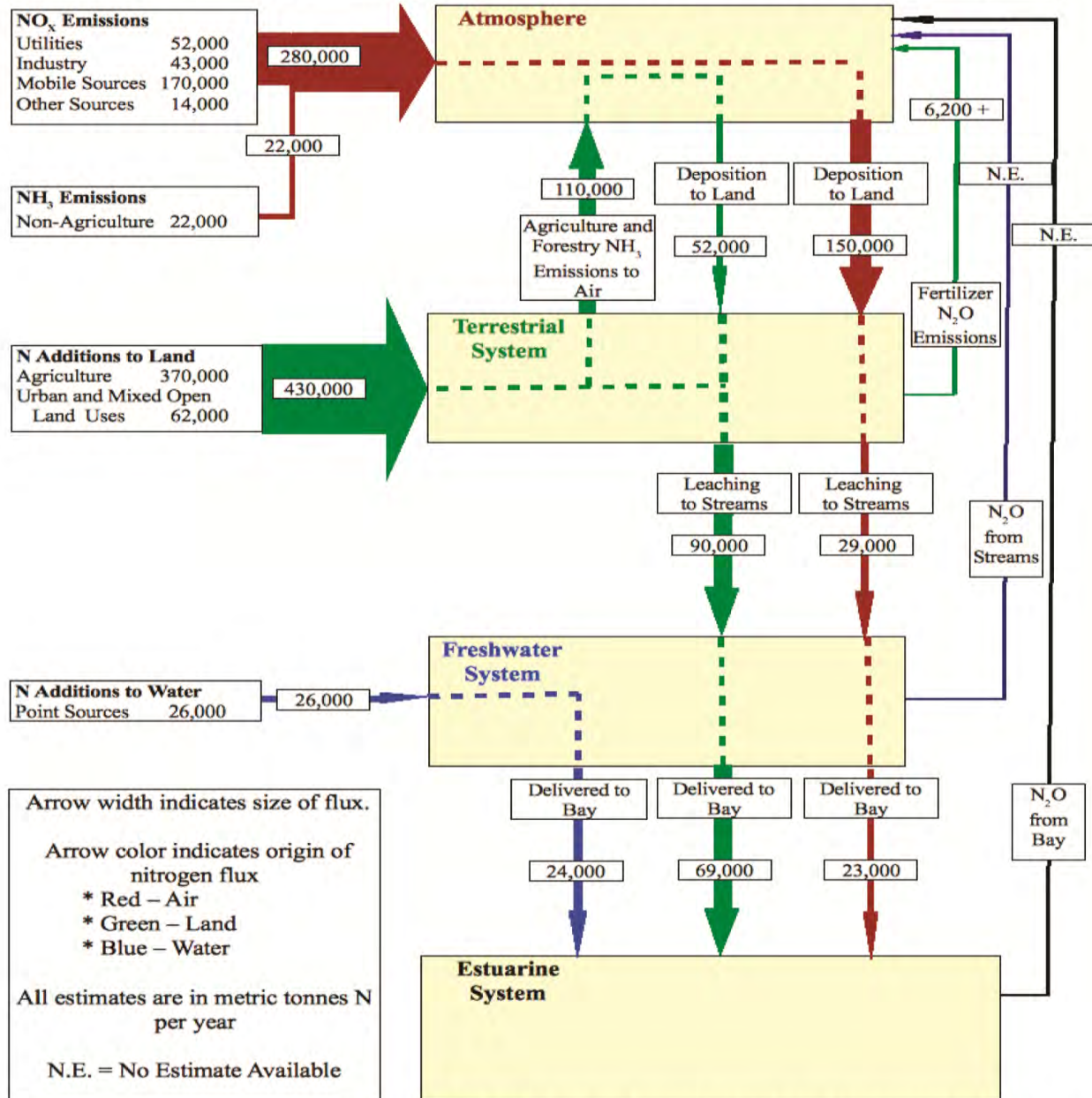


FIGURE 1. Chemical Nitrogen Cascade in the Chesapeake Bay Watershed (tonnes/year). See SI for sources and calculations.

Economic Nitrogen Cascade: Chesapeake Bay Watershed

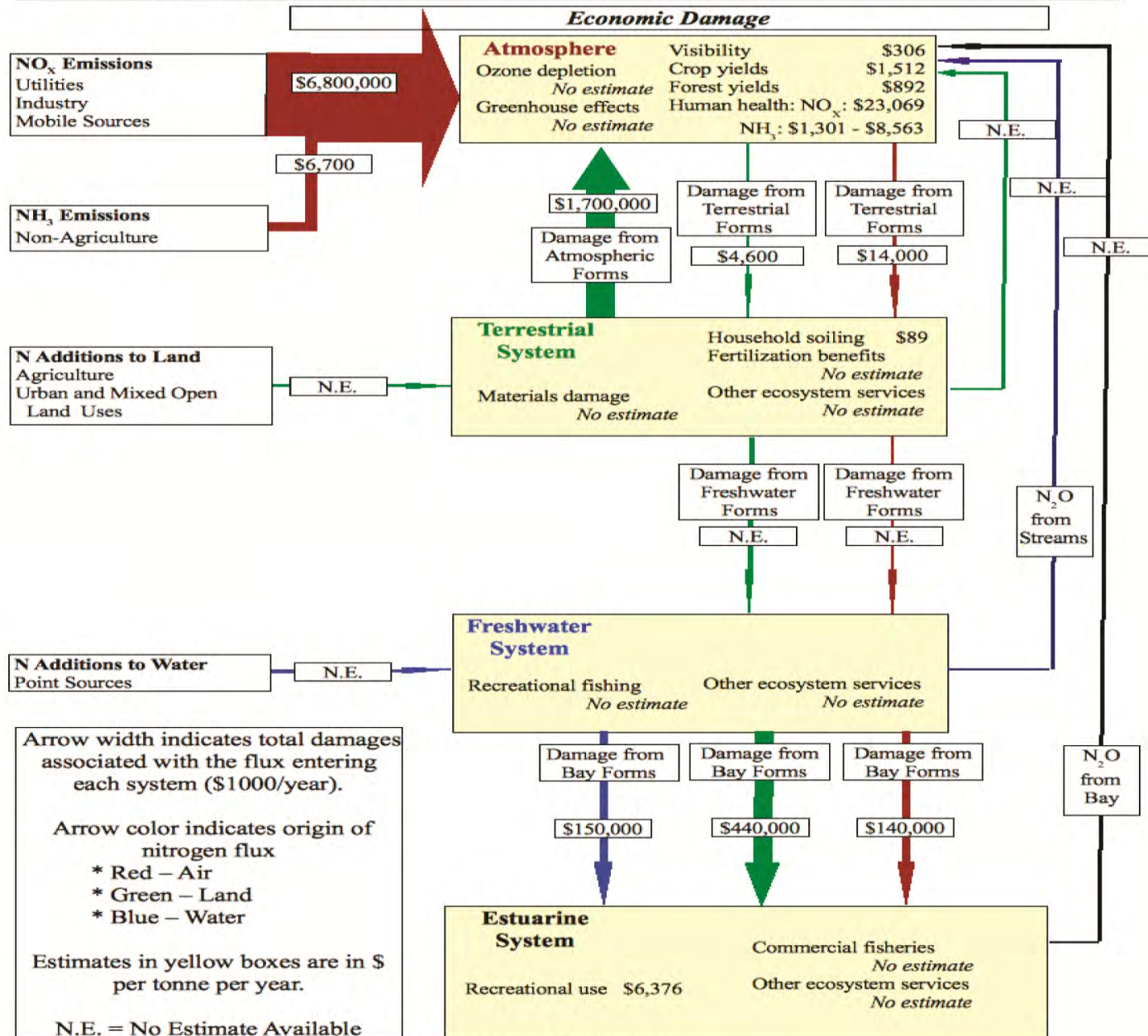


FIGURE 2. Economic Damage Cascade. See SI for sources and calculations.

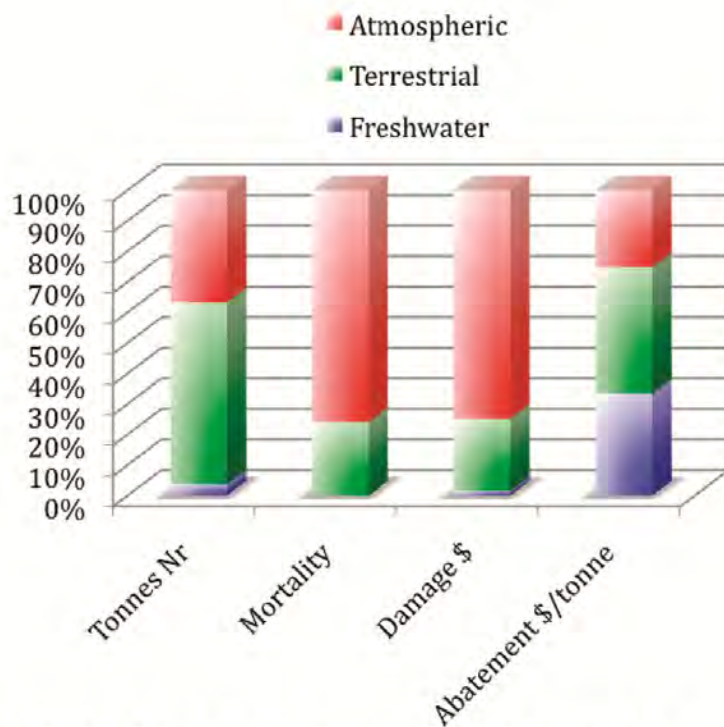


FIGURE 3. Share of contributions from all reactive nitrogen sources in the Chesapeake Bay watershed according to different metrics.

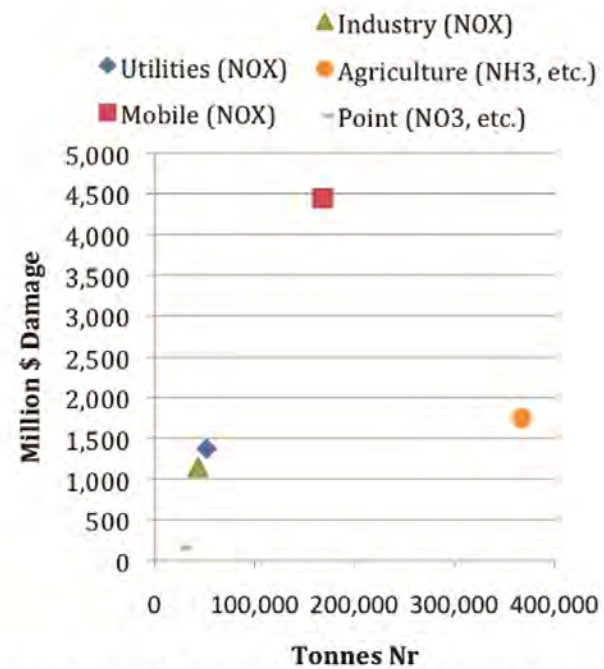


FIGURE 4. Quantified damage costs (including health impacts) relative to tonnes of reactive nitrogen.

Final Thoughts:

- The biophysical Cascade shapes the problem and the response.
- Responses to Nr must be integrated within and between institutions.
- Some re-alignments of institutions, regulatory & voluntary and point & non-point boundaries will be required for further progress.
- Cost effectiveness encompasses multiple media, sectors, approaches, and metrics.
- Appropriate, or more likely multiple metrics need to be chosen as appropriate for societal goals.
- We make little progress if we do not set realistic goals and take action.



Our Earth